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Effects of extra feeding during mid-pregnancy on gilts productive and reproductive performance

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Abstract

The effects of a supplemental feeding strategy during mid-gestation on lean gilts body reserves, productive and reproductive performance were assessed. A total of 90 gilts were allocated into two treatments (Control, C, and Supplemented, S). Control sows (n = 43) were fed according to the level routinely used on farm (2.5-3.0 kg d^{-1}, 2.9 Mcal metabolizable energy kg^{-1} feed and 0.6% of lysine) throughout gestation, and S sows (n = 47) received 50% more feed from day 45 to day 85 of gestation. Body weight (BW) and sows body condition [backfat (BF), loin depth and body condition score] were recorded on days 40 and 80 of gestation, at farrowing and at weaning. Litter performance at birth and on day 18 ± 1 of lactation was registered at first and second parities. Although no differences in backfat levels were found at weaning, a higher proportion of S sows stayed within the target backfat interval both at farrowing (17-21 mm) and at weaning (> 14 mm). No differences were found in BW and body reserves losses during lactation between treatment groups. Litter weight at birth tended to be higher in the S group of sows, consistently, in the first and second parities ($P < 0.10$), compared to the C group. Thus, providing an extra feed allowance during mid-gestation has beneficial effects on gilts' body fat reserves at weaning (higher proportion of sows in the optimum BF interval) and slight advantages on productive output, although probably not high enough to justify the extra feed wastage.

Additional key words: backfat, gilt performance, loin depth, maternal nutrition.

Resumen

Efectos de un aporte extra de alimento durante la parte central de la gestación en los rendimientos productivos y reproductivos de cerdas nulíparas

Se evaluaron los efectos de un incremento del nivel de alimentación en gestación media sobre las reservas corporales y los rendimientos productivos de cerdas nulíparas magras. Un total de 90 cerdas fueron distribuidas en dos tratamientos (Control, C, y Suplementado, S). Las cerdas C (n = 43) se alimentaron según el patrón de alimentación habitual en granja en gestación (2,5-3,0 kg d^{-1}, 2,9 Mcal energía metabólica kg^{-1} de pienso y 0,6% de lisina). Las cerdas S (n = 47) recibieron un 50% más de alimento entre los días 45 y 85 de gestación. El peso vivo (BW), espesor de grasa dorsal (BF), profundidad de lomo y nota de condición corporal de las cerdas se midieron a los 40 y 80 días de gestación, al parto y al destete. Los rendimientos al nacimiento y el día 18 ± 1 de lactación fueron registrados en los dos primeros partos. Aunque no hubo diferencias en el nivel de BF al destete, hubo una mayor proporción de cerdas S dentro del intervalo de BF óptimo al parto (17-21 mm) y al destete (> 14 mm). No se encontraron diferencias entre tratamientos en las pérdidas de BW y reservas corporales en lactación. El peso medio de camada al nacimiento resultó mayor en las cerdas S ($P < 0,10$) en los dos partos estudiados. En conclusión, un aporte extra de alimento durante la gestación media resultó en beneficios sobre las reservas grasas de cerdas nulíparas al destete, y en un ligero pero positivo efecto en los rendimientos productivos, aunque éstos difícilmente compensan el aporte extra de alimento.

Palabras clave adicionales: espesor de grasa dorsal, nutrición materna, profundidad de lomo, rendimientos cerda nulípara.

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Introduction[1]

The higher productivity currently expected for the new hyperprolific and leaner sows is not achieved on most farms. Modern sows show higher culling rates due to reproductive failure and a reduced post-weaning and lifetime performance than that of some years ago (Eissen *et al.*, 2000). This has been related both to an excessive body weight and body reserves losses during lactation and to a suboptimum level of body reserves of either fat or lean tissue at weaning of these genotypes (Koketsu *et al*., 1996; Clowes *et al*., 2003). Otherwise, the restricted feeding strategy normally used during gestation does not always allow recovering body reserves in the subsequent parity cycle. This is particularly harmful in gilts, since they have lower body reserves and a 20% lower voluntary feed intake (VFI) during lactation compared to multiparous sows (Young *et al*., 2005) and also, they need extra energy to achieve optimum growth rates. Thus, it seems necessary to review feeding strategies and to adapt them to meet the feeding requirements of the leaner sow, particularly in gilts.

Increasing feed intake during gestation should help to guarantee higher levels of body reserves at farrowing and at weaning. On the other hand, it is well established that increased backfat levels at farrowing lead to a decrease in VFI during lactation (Dourmad, 1991; Revell *et al*., 1998a; Sinclair *et al*., 2001). Many years ago it was demonstrated that this effect was only significant at backfat thickness (BF) levels of 25 mm or greater at farrowing (Mullan and Williams, 1989). But, in the current leaner genotypes this threshold may have changed or might have different consequences. In fact, more recent studies suggest that high amounts of body reserves at farrowing could play a protective role on post-weaning performance against detrimental effects of an excessive body weight loss during lactation, at least in lean genotypes (Dourmad *et al*., 1994; Quesnel *et al*., 2005).

Probably, the best time point to increase feeding level is mid-gestation in order to avoid possible embryo mortality in early gestation (Dick and Strain, 1983), as well as avoiding negative effects on mammary gland development and, therefore, milk production in late gestation (Weldon *et al*., 1991). Additionally, previous studies have suggested that maternal feeding during this period might impact foetal growth and development (Schoknecht *et al*., 1993; Dwyer *et al*., 1994).

The purpose of the present study was to determine the impact of increasing feed allowance during mid-gestation in first parity sows on their body reserves management, productivity and lactation, and post-weaning performance. To the authors' knowledge, this area of sow nutrition has not previously been addressed.

Material and Methods

Experimental design

The experiment was conducted on a sow farm (Santa Ana, Soria, Spain) and received previous approval from the Animal Protocol Review Committee of the Universitat Autònoma de Barcelona. The study involved a total of 90 Landrace × Large White PIC gilts that were selected on day 40 of gestation (after positive pregnancy check) at an average weight (± SD) of 156 ± 14.9 kg. They were divided into two treatments, Control (C, n = 43) and Supplemented (S, n = 47). Gilts were assigned randomly to one of the two treatments according to the day of mating, body weight (BW) and body condition [BF, loin depth (LD) and body condition score (BCS)] on day 40 of gestation.

The C group of sows was fed throughout gestation at the level routinely used on farm according to sows' BCS at mating (2.5-3.0 kg d^{-1}, 2.9 Mcal ME kg^{-1} feed). The S group received 50% more of the same feed than group C from day 45 to day 85 of gestation; feed allowance was calculated for each sow individually, and the desired feeding level was gradually reached in 4 days (from day 41 to day 45 of gestation). From day 85 of gestation until farrowing, the amount of feed provided to group S was the same for all gilts and was calculated as the average level of the C sows at that time. Composition of the feed is given in Table 1.

During gestation, sows were housed in individual stalls and fed twice a day (08:00 h and 14:30 h). Gilts were moved to the farrowing crates about one week before farrowing (110 days of gestation) and, from this

[1] Abbreviations used: ADFI (average daily feed intake), AFD (apparent faecal digestibility), APW (average piglet weight), BCS (body condition score), BF (backfat), BW (body weight), C (control group), CV (coefficient of variation), IU (international units), LD (loin depth), S (supplemented group), SEM (standard error of the mean), VFI (voluntary feed intake), WEI (weaning to oestrus interval).

Table 1. Composition of the gestation and lactation diets (as-fed basis)

	Gestation diet	Lactation diet
Ingredient, %		
Barley	33.7	25.7
Wheat bran	33.3	17.5
Sugar beet molasses	5.2	3.6
Wheat	5.7	12.5
Cassava meal	—	6.5
Soybean meal, 44% crude protein	4.9	18.4
Sunflower meal	9.3	6.4
Animal fat	3.4	6.0
Calcium carbonate	1.37	1.57
Sodium chloride	0.25	0.45
Monocalcium phosphate	0.17	0.71
L-Lysine HCl-50%	0.03	0.16
Choline chloride-75%	0.01	0.02
Vitamin and mineral premix[1]	0.50	0.50
Calculated analysis		
Metabolizable energy (kcal kg^{-1})	2,899	3,080
Dry matter (%)	88.79	89.13
Crude fat (%)	7.26	7.79
Crude protein (%)	14.57	17.18
Lysine (%)	0.62	0.89
Crude fiber (%)	7.52	6.44
Ash (%)	5.73	6.71
Calcium (%)	0.70	0.91
Available phosphorus (%)	0.26	0.33

[1] Provided per kilogram of feed: 10,000 IU of vitamin A; 2000 IU of vitamin D3; 40 mg of vitamin E; 6 mg of vitamin K; 1 mg of vitamin B1; 6 mg of vitamin B2; 0.02 mg of vitamin B12; 29 mg of nicotinic acid; 11.71 mg of pantothenic acid; 0.5 mg of folic acid, 0.06 mg of biotin; 80 mg of Fe; 25 mg of Cu; 0.40 mg of Co; 100 mg of Zn; 43.20 mg of Mn; 2.25 mg of I and 0.09 mg of Se.

time, the lactation diet was fed. The average lactation length was 22 ± 2 days. Feed during lactation was given as dry feed twice a day (08:00 h and 14:30 h) and gilts had free access to water via nipple drinkers. Feeding level during lactation was increased gradually at a rate of 0.550 kg d^{-1}, from 0 kg d^{-1} at the day of farrowing to a maximum of 7.7 kg d^{-1}, reached on day 14 of lactation.

Routine farm management procedures were followed in caring for the sow and litter during parturition and lactation. Litter size was adjusted to 10-11 pigs per litter at 24 h post-farrowing, and cross-fostering was minimized and allowed only within treatments. No creep feeding was provided to the piglets during lactation. Male piglets were castrated on the 7th day of age.

Measurements

Gilts were weighed on day 40 of gestation, at 48 ± 24 h post-farrowing and at weaning. Backfat and LD were measured at the P2 position (above the last rib at approximately 6.5 cm of the midline) using an A-mode ultrasound (Renco sonograder 4.2, Renco Corporation, Minneapolis, MN), on days 40, 80 and 110 of gestation and on day 18 ± 1 of lactation. The point of the initial scan was marked to ensure that subsequent scans were recorded at the same place. Body condition score was recorded visually, according to a 1 to 5 score subjective scale (Close and Cole, 2003) at the time of ultrasounding. Lipid and protein content of the animals were mathematically estimated through the prediction equations developed by Dourmad *et al*. (1997).

Feed refusals during gestation were controlled throughout the experimental period (45 to 85 days of gestation) in order to ensure that all the animals ate the whole amount of feed offered. In a sample of animals (n = 21, C = 11 and S = 10), the apparent faecal digestibility (AFD) of organic matter was measured by day 60 of gestation using the acid-insoluble ash method (Van Keulen and Young, 1977), after a one week adaptation period to the acid-insoluble ash external marker added to the gestation feed (1%, as dry matter basis).

Throughout lactation, the average daily feed intake (ADFI) was measured in a sample of gilts (n = 19, C = 10 and S = 9) over 12 randomly selected and non-consecutive days of lactation. No intake records for the first four days of lactation were taken. Feed refusals were weighed and one homogeneous sample of each refusal (approx. 200 g) was frozen to allow subsequent determination of dry matter content at 70°C, following AOAC (1995) procedures. The amount of feed dry matter consumed per day was calculated as the difference between the dry matter offered and the refused. Data were pooled by treatment and day of lactation and differences in ADFI in the two treatments were analysed. Apparent faecal digestibility of organic matter was also measured on day 15 ± 1 of lactation in the same sample of gilts (n = 19), after a one week adaptation period to the acid-insoluble ash external marker added to the lactation feed (1.5%, as dry matter basis).

At farrowing, piglets including total, alive, stillborn and mummies were counted and individually weighed. The number of pigs and their weight were recorded again after cross-fostering and on day 18 ± 1 of lactation, in order to homogenise the lactation length among litters. Milk production was estimated using the average piglet weight gain during lactation and applying a milk:gain factor of 4 L kg^{-1} (Pluske and Dong, 1998). Lactation incidences in sows and pigs, piglet mortality and causes of death were also recorded. The weaning to oestrus interval (WEI), defined as the interval from weaning to first mating, and the percentage of sows culled were determined. Sows with WEIs longer than 6 days and those returning to oestrus after the first insemination were not considered for reproductive performance in their second reproductive cycle. Finally, litter characteristics were also obtained in the second parity, when sows received, again, the mid-gestation feeding treatment that was applied in the first parity cycle.

Statistical analyses

Data was analysed using SAS® package (SAS Institute, 2001). In all the analysis procedures, gestation feeding level served as treatment and unique main factor, and the sow was considered as the experimental unit. Tukey test was used in order to compare least-square means (LSMEANS).

The body condition management during gestation and lactation (BW, BF, LD and BCS) was analysed according to a repeated measures model using the MIXED procedure of SAS. Changes in body condition (BW, BF, LD and estimated body composition) during gestation and lactation, AFD and WEI were analysed through a one-way analysis of variance model using the GLM procedure of SAS. In addition, BW changes during lactation were covariated by the lactation length term.

The number of total born, born alive and pigs on day 18 ± 1 of lactation were analysed through a statistical model for categorical data (GENMOD procedure of SAS), and litter and average piglet weight (APW) were evaluated using an analysis of variance model (GLM procedure of SAS). The litter size factor was used as a covariate for litter weight and APW. In litter weight and APW on day 18 ± 1 of lactation litter weight and APW after cross-fostering were also used as covariate terms.

Average daily feed intake (ADFI) during lactation was analysed through a two-factor analysis of variance model (GLM procedure of SAS) considering both, the feeding level during gestation and the day of lactation as main factors.

Pearson's correlation coefficients were calculated using the CORR procedure of SAS to test the correlation among sow body condition parameters and productive performance.

An alpha of $P < 0.05$ was declared as significant, whereas trends were discussed when $0.06 < P < 0.10$.

Results

Changes in body weight and body reserves

The extra feed allowance provided to the gilts from the S group during the experimental period led to a slightly lower AFD of organic matter compared to the C group (C = 76.6% and S = 75.4 %, SEM = 0.004 and P = 0.033).

Body weight and body reserves evolution throughout the first-parity cycle is summarized in Table 2. At allocation (day 40 of gestation), BW, BF and LD levels were similar between treatment groups. Increasing feeding level during mid-gestation did not cause differences on BW nor in LD management along the first parity cycle between treatment groups. However, BF levels at the end of the experimental period (day 80 of gestation) were significantly higher in the supplemented compared to the C group of sows (C = 16.8 mm and S = 18.3 mm, P = 0.010), although these differences were reduced at farrowing (C = 16.9 mm and S = 17.9 mm, P = 0.099), and they disappeared at weaning (C = 13.5 mm and S = 14.3 mm, P = 0.195).

Additionally, sows BF distribution on day 40 of gestation, at farrowing and at weaning was studied and shown in Figures 1, 2 and 3, respectively. On day 40 of gestation, both treatment groups showed similar percentages of sows showing between 15 and 20 mm of BF (C = 58.2% and S = 60.9%). At farrowing, the percentage of sows within the optimum BF interval suggested by Young *et al.* (2004) at this time (17 to 21 mm) was higher in the S compared to the C group of sows (S = 46.8% and C = 32.6%). At weaning, the proportion of sows with more than 14 mm of BF was also higher in the S compared to the C group of sows (S = 42.9% and C = 31.7%).

Regarding BCS, it was maintained around 3.0 during all the gestation period. At weaning, it was lower than 3.0 in both treatment groups, and the average BCS was higher in the S compared to the C group of gilts (C = 2.4 and S = 2.7, P = 0.007).

Results of the total balance of body reserves (from day 40 of gestation until weaning) showed that gilts

Table 2. Body weight (BW), backfat thickness (BF), loin depth (LD) and body condition score (BCS) throughout the first parity cycle

	Control group	Supplemented group	SEM	P
BW (kg)				
Initial (40 days gestation)	155.4	156.8	2.28	0.670
Post-farrowing[1]	179.2	184.3	2.23	0.152
Weaning	168.5	170.7	2.67	0.558
BF (mm)				
Initial (40 days gestation)	15.4	16.1	0.48	0.332
80 days gestation	16.8	18.3	0.43	0.010
Farrowing	16.9	17.9	0.46	0.099
Pre-weaning[2]	13.5	14.3	0.45	0.195
LD (mm)				
Initial (40 days gestation)	56.7	55.2	0.78	0.106
80 days gestation	59.8	60.6	0.83	0.392
Farrowing	59.9	61.0	0.76	0.183
Pre-weaning[2]	55.9	56.9	0.77	0.254
BCS				
Initial (40 days gestation)	3.1	3.1	0.05	0.230
80 days gestation	3.0	3.2	0.05	0.067
Farrowing	3.0	3.1	0.06	0.251
Pre-weaning[2]	2.4	2.7	0.08	0.006
Total balance[3]				
BW (kg)	14.5	16.4	2.00	0.493
BF (mm)	–1.75	–1.12	0.379	0.232
LD (mm)	0.02	1.30	0.975	0.143
Lipid (kg)[4]	0.50	2.42	0.802	0.085
Protein (kg)[4]	3.06	3.45	0.312	0.372

Results are expressed as least square means and SEM. *P*-value in the table is that corresponding to treatment * time factor. [1] Post-farrowing: 48 ± 24 h post-farrowing. [2] Pre-weaning: day 18 ± 1 of lactation. [3] Total balance: BW, BF, LD, estimated lipid and protein content change from day 40 of gestation until weaning. [4] Estimated values using the prediction equations of Dourmad *et al.* (1997) [Lipid (kg) = –26.4 + (0.221 × EBW) + (1.331 × BF) and Protein (kg) = 2.28 + (0.178 × EBW) – (0.333 × BF), where EBW (empty body weight) is 0.912 × (BW1.013) at 40 days of gestation and at farrowing, and 0.905 × (BW1.013) at weaning].

gained BW and estimated body protein, and that they lost BF, similarly, in both treatment groups. However, S sows tended to gain higher estimated lipid reserves and had numerically higher LD gains than C sows at the end of the first reproductive cycle.

When maternal BW and body reserves changes during gestation and lactation were analysed separately (Table 3), gilts receiving the higher feeding level during mid-pregnancy tended to show higher absolute and relative (in percentage) gains of BW, BF and LD from day 40 of gestation until farrowing ($P < 0.10$) than C sows. However, BW, BF and LD losses during lactation were not different between treatments.

Litter characteristics, feed intake during lactation and rebreeding performance

The total number of pigs born, born alive, stillborn and mummies were not affected ($P > 0.10$) by the feeding level during mid-gestation (Table 4). However, litter weight of total born and born alive tended to be higher in the S group ($P = 0.065$ and $P = 0.081$, respectively) compared to the C group of sows.

On day 18 ± 1 of lactation, piglet performance and milk production were not different between treatments (Table 5). Intra-litter piglet weight homogeneity, estimated through the coefficient of variation (CV) intra-

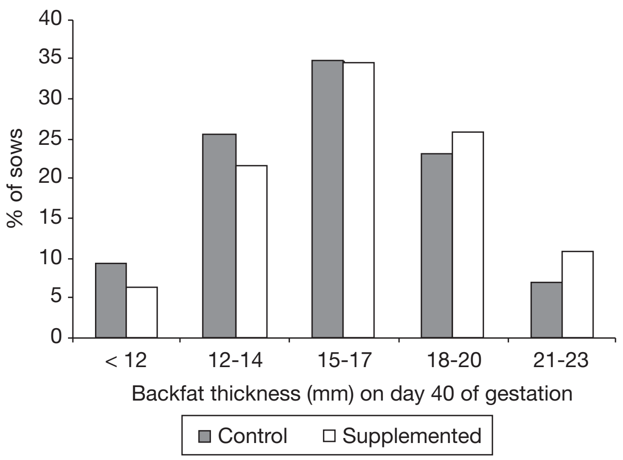

Figure 1. Percentage of sows (%) plotted by backfat thickness (BF) on day 40 of gestation.

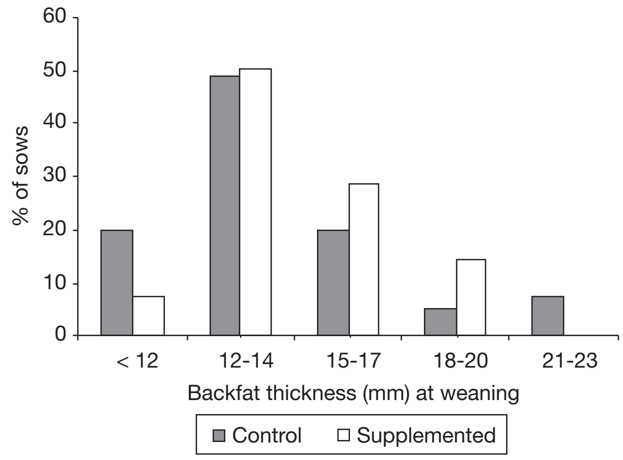

Figure 3. Percentage of sows (%) plotted by backfat thickness at weaning.

litter, was similar between experimental treatments both at birth (Table 4) and on day 18 ± 1 of lactation (Table 5). Overall, piglet mortality during lactation (after cross-fostering until day 18 ± 1 of lactation) was low, although numerically higher in the C group (C = 9.44% and S = 6.90%, P = 0.224) compared to the S group of sows. The incidence of the different causes of piglet death recorded did not differ between treatments. In both groups of treatment, crushed by the sow was the main cause of death representing a 50.9 and a 55.5% of the overall pig mortality during lactation in groups C and S, respectively.

It was not possible to determine the maximum feed intake achieved by the sows during lactation in both treatments, since feed allowance during lactation was not rigorously *ad libitum*. However, taking this fact into account, S sows showed lower ADFI compared to C sows throughout all the lactation period (as fed-basis, S = 5.44 kg d^{-1} and C = 5.78 kg d^{-1}, SEM = 0.089 and P = 0.011), and also in the period from day 14 of lactation until weaning, that is when the maximum feeding level was offered (as fed-basis, S = 6.72 kg d^{-1} and C = 7.19 kg d^{-1}, SEM = 0.150 and P = 0.047). The AFD of organic matter determined on day 15 ± 1 of lactation was lower in the C compared to the S group of sows, but large standard errors prevented these differences from attaining significance (C = 73.4% and S = 74.4 %, SEM = 0.027 and P > 0.10).

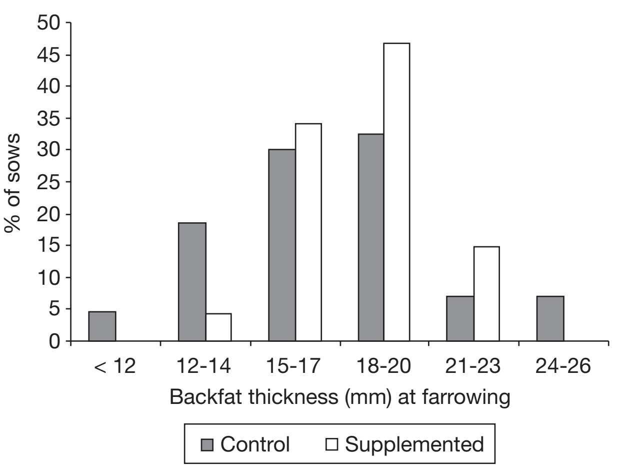

Figure 2. Percentage of sows (%) plotted by backfat thickness at farrowing.

Table 3. Changes in net maternal body weight (BW), backfat thickness (BF) and loin depth (LD) expressed in absolute values and as a percentage of the initial values (in brackets)[1] throughout gestation and lactation

	Control group	Suplemented group	SEM	P
Gestation gain[2]				
BW (kg)	24.8 (16.1)	28.2 (18.4)	1.355	0.065
BF (mm)	1.7 (12.1)	2.5 (19.5)	0.325	0.056
LD (mm)	3.7 (7.2)	5.2 (9.9)	0.590	0.071
Lactation loss				
BW (kg)[3]	–10.0 (5.5)	–12.6 (6.9)	1.493	0.209
BF (mm)[4]	–3.5 (20.2)	–3.6 (19.9)	0.251	0.655
LD (mm)[4]	–3.8 (6.0)	–4.1 (6.5)	0.759	0.836

Results are expressed as least square means and SEM. [1] Initial values considered are day 40 of gestation for gestation changes and farrowing for lactation changes. [2] Gestation gains from 40 days of gestation until farrowing. [3] From farrowing until weaning. [4] From farrowing until 18 ± 1 days of lactation.

Table 4. Productive performance per sow at birth in the first parity cycle

	Control group	Suplemented group	SEM	P
Total born				
Litter size	12.7	12.1	0.386	0.407
Litter weight (kg)	16.2	17.0	0.308	0.065
CV (%)[1]	17.9	18.5	0.009	0.642
APW2 (kg)	1.308	1.365	0.025	0.106
Born alive				
Litter size	11.8	11.5	0.359	0.165
Litter weight (kg)	15.4	16.1	0.308	0.081
APW[2] (kg)	1.317	1.369	0.027	0.162
Stillborn (n)	0.88	0.59	0.145	0.101
Mummies (n)	0.37	0.25	0.103	0.308

Results are expressed as least square means and SEM. [1] CV: coefficient of variation of the average piglet weight intralitter. [2] APW: average piglet weight.

Culling rates during the first parity cycle (from day 40 of gestation until mating in the next cycle) were higher in the S group of sows compared to the C group (C = 7.0% and S = 14.9%). Although most of the reasons for culling were not related to the experimental treatment, it is important to point out that two gilts belonging to the S group were removed due to mamitis-metritis-agalactia syndrome (MMA). Also, a total of 3 sows were removed due to long WEI (> 20 days), 1 from the C and 2 from the S group.

Table 5. Productive performance per sow on day 18 ± 1 of lactation in the first parity cycle

	Control group	Suplemented group	SEM	P
Litter size	9.9	10.2	0.181	0.147
Litter weight (kg)	49.1	47.9	1.023	0.415
CV (%)[1]	19.7	20.4	0.012	0.682
ADG (kg d^{-1})[2]	2.03	1.94	0.067	0.339
APW (kg)[3]	4.85	4.72	0.099	0.376
Piglet mortality (%)[4]	9.44	6.90	1.498	0.224
Milk production (L d^{-1})[5]	8.12	7.76	0.268	0.339

Results are expressed as least square means and SEM. [1] CV: coefficient of variation of the average piglet weight intra-litter. [2] ADG: average litter daily gain after cross-fostering until 18 ± 1 days of lactation. [3] APW: average piglet weight. [4] After cross-fostering until 18 ± 1 days of lactation. [5] Estimated values calculated using litter ADG and a conversion factor for milk of 4 L kg^{-1} piglet body weight growth (Pluske and Dong, 1998).

Table 6. Productive performance per sow at birth in the second parity cycle

	Control group	Suplemented group	SEM	P
Total born				
Litter size	12.4	11.7	0.640	0.511
Litter weight (kg)	16.8	18.0	0.516	0.099
APW[1] (kg)	1.419	1.522	0.040	0.071
Born alive				
Litter size	11.9	11.0	0.638	0.413
Litter weight (kg)	15.8	17.1	0.487	0.065
APW[1] (kg)	1.431	1.527	0.041	0.099
Stillborn (n)	0.57	0.78	0.214	0.395
Mummies (n)	0.24	0.22	0.106	0.886

Results are expressed as least square means and SEM. [1] APW: average piglet weight.

After weaning, WEI was not different between treatment groups (C = 4.7 d and S = 5.0 d, P = 0.132). A total of 40 sows from each experimental group were mated within 6 days post-weaning in their second parity. Farrowing rates in the subsequent parity [(farrowed sows/mated sows) * 100)] were also not different between parity groups (80% in both treatments).

In the subsequent parity (second parity), no differences were found either in the number of piglets total born, born alive, stillborn or mummies (Table 6). However, the total born and born alive average litter weights and APWs tended to be, again, higher in the S group of gilts (P < 0.10) compared to the C group.

Discussion

Maternal feed intake and changes in BW and body reserves

Sows lifetime performance strongly depend on body reserves management over their reproductive life. In lean genotypes, the amount of body reserves (lean and fat) at weaning is described as essential to guarantee a high subsequent productivity and a long lifetime performance (Whittemore, 1996; Eissen *et al*., 2000; Clowes *et al*., 2003). Data from several studies have shown that levels lower than 14 mm of BF at weaning may compromise subsequent reproductive performance (Young *et al*., 1991; Tantasuparuk *et al*., 2001). Thus, it is desirable for gilts to have more than 15 mm of BF at first mating and between 17 and 21 mm of BF at farrowing to allow them to lose 2 to 3 mm of BF during lactation, and not fall below 14 mm at their subsequent service. In the present experiment, both groups of treatment achieved the average of 17 mm desired at farrowing, but S sows tended to have higher BF levels than C sows at this time (Table 2). These differences were not maintained through weaning, when both groups had around 14 mm of BF. However, BF levels at farrowing resulted strong and positively correlated with BF levels at weaning ($r = 0.84$, $P < 0.001$) indicating that, in general, the implementation of a feeding strategy that increases BF levels at farrowing might also assure higher BF levels at weaning.

Due to the high variability that normally exists in BF levels among individuals, these results were alternatively studied using frequency distribution graphs since they offer a better approximation to the actual situation on farm. As a result, although both experimental groups showed a similar proportion of sows between 15 and 20 mm of BF on day 40 of gestation, a higher percentage of sows were maintained within the optimum BF interval at farrowing (17 to 21 mm) and at weaning (> 14 mm). Also, the proportion of sows with 10 mm or less BF, which is considered a threshold below which sow lifetime performance is strongly impaired (Young *et al*., 1990; Kongsted, 2006), was also lower in the S compared to the C group of sows (S = 7.1% and C = 19.5%). In short, the supplemental feeding strategy implemented in the present study provides advantages in terms of the proportion of sows in the optimal backfat categories at farrowing and at weaning.

In general, BF levels reported in the present experiment were very far from those recommended by other authors for gilts: 20 mm at first mating, 24 at farrowing and 22 at weaning (Mullan and Williams, 1989; Close and Cole, 2003). In fact, no more than 18% of sows had levels of 20 mm or higher of BF on day 40 of gestation in the specific genetic line used in this trial (Fig. 1). This indicates that the recommended BF and gain values must be adapted to each genetic line and commercial conditions.

Regarding BCS, statistical differences between treatments were detected on day 80 of gestation and at weaning (Table 2). In the present experiment, according to other authors (Maes *et al*., 2004), BCS showed a low to moderate correlation with BF levels ($r = 0.44$, $P < 0.001$). Although with lower correlation coefficients, BCS was also positively correlated with LD and BW ($r = 0.36$ and $r = 0.25$, respectively, $P < 0.001$). This fact suggests that the body condition scoring evaluation on farm in first parity sows mainly predicts fat reserves (BF), but that BCS may also be influenced by the lean conformation (LD) and sow BW.

The most common equations used to predict body composition (Whittemore and Yang, 1989; Dourmad *et al*., 1997) estimate sows body protein content using BF and BW values. However, the relation between sow BF and body protein content may well be now very different from that found some years ago, due to the strong genetic selection for lean tissue that the modern lines have gone through. In fact, the correlation obtained between the estimated body protein and LD levels measured in this study was low to moderate ($r = 0.42$, $P < 0.001$). From these results and in agreement with a study on lactating cows (Bullock *et al*., 1991), the use of a more direct measurement of the muscle such as ultrasonic LD could be better suited in order to estimate body protein content in these modern genotypes instead of, or additionally, to BF values.

Gestation is an anabolic event in the sow's life, representing the period of highest weight and body reserves gains of all the reproductive cycle. During their first parity cycle, sows are still growing and they should increase their BW and also accumulate body reserves for subsequent parities. In the present study, the extra feed allowance provided during mid-gestation tended to increase BW, BF and LD gains from day 40 of gestation until farrowing (3.4 kg BW, 0.8 mm BF and 1.5 mm LD more in the S compared with the C group) although, contrary to other studies (Mullan and Williams, 1989; Dourmad, 1991; Revell *et al*., 1998a; Sinclair *et al*., 2001) this fact did not result on differences in lactation BW and body reserves losses.

In the present experiment, the BW and body reserves total balance at the end of the first parity cycle showed that both groups of gilts gained similar amounts of BW, and that these gains were followed by a negative BF balance. This indicates that sows were not able to maintain BF levels at the end of their first parity cycle, even when an extra feed allowance during mid-pregnancy was provided. As it has been previously described (Dourmad, 1991), results from the present study also demonstrate that gilts can gain BW and lose BF at the same time, suggesting the limited usefulness of BW changes to predict changes in BF and thus, undertake a sow feeding strategy based on body fat reserves. The present results also suggest, according to other studies (Whittemore and Morgan, 1990; Pettigrew and Yang, 1997), that BW gain in pregnant gilts was mainly in the form of protein and less in the form of fat.

An inverse relationship between feed intake during gestation and the voluntary feed intake during lactation has been documented by many authors in the literature (Dourmad, 1991; Weldon *et al*., 1994; Revell *et al*., 1998a; Sinclair *et al*., 2001). This has been mainly attributed to the level of fatness at parturition (Mullan and Williams, 1989; Sinclair *et al*., 2001; Young *et al*., 2004). But there is no agreement in the literature on the level of feed intake during gestation or BF levels at farrowing above which feed intake during lactation is reduced. It has been reported that increases in BF from 17.3 to 24.3 mm during gestation involve a decrease of 1.6 kg d^{-1} in the lactation feed intake in primiparous sows (Revell *et al*., 1998a). But lower decreases in the voluntary feed intake (0.620 kg d^{-1}) have been related with larger increases in BF levels during gestation (from 17.8 to 29.2 mm; Dourmad, 1991). Actually, this negative relationship between BF and voluntary feed intake during lactation might not be linear. In this regard, it has been reported that the decrease on feed intake during lactation was significant when primiparous sows showed more than 25 mm of BF at farrowing (Mullan and Williams, 1989).

In the present study, as the feed supplementation accounted for a short period of gestation (40 days), differences in BF at farrowing between treatments were low. In the subsample of sows used to determine ADFI during lactation ($n = 19$), BF gains during gestation were numerically higher in the S compared to the C group of sows (C = 3.9 mm and S = 5.1 mm, $P = 0.193$) those achieving mean levels of 18.8 and 20.0 mm of BF, respectively, at weaning. In this case, an increase in BF from 14.1 to 20.0 mm (in the S group) showed a decrease in lactation ADFI of 320 g d^{-1} in average, which is similar to that found by Dourmad (1991) per mm of BF. However, this difference in feed intake during lactation did not lead to significant differences on BW and body reserves loss during lactation between treatment groups.

Productive and reproductive performance

Effects of feeding level during gestation on litter performance are controversial in the literature. In most of the studies, no effect is described (Young *et al*., 1990; Dwyer *et al*., 1994; Sinclair *et al*., 2001). However, in some others, higher levels of feeding lead to heavier piglets at birth (Aherne and Kirkwood, 1985; Coffey *et al*., 1994). These differences among studies might be due to differences on the amount of energy and nutrients, the length of time and the period of gestation in which the feed supplementation is provided. Generally, heavier pigs at birth have been related with higher feeding levels during the last month of gestation (Aherne and Kirkwood, 1985; Cromwell *et al*., 1989), when most of the foetal growth takes place. But some authors suggest that this effect only occurs when birth weights are lower than 1.0 kg pig^{-1} (Aherne and Kirkwood, 1985; Whittemore, 1996). In the present study, the higher feed allowance provided during mid-gestation resulted on heavier litters at birth ($P < 0.07$). This effect seemed to be consistent since it also appeared on the second parity, when both litter weight and APW at birth tended to be higher in the S compared to the C group of sows ($P < 0.10$), in spite of having birth weights of about 1.3 kg pig^{-1}. One possible explanation to this fact is that, although short in time, the window time when the higher feed allowance was provided in this study, may have an effect on foetal development as it coincides with the period of the secondary muscle fibres formation *in utero*. In fact some studies have reported a positive relationship between piglet weight at birth and the number of muscle fibres, so that the smallest pigs the lower number of muscle fibres at birth (Gondret *et al*., 2006; Rehfeldt and Khun, 2006). More investigations in this field are needed.

During lactation, litter ADG was similar to the obtained in other studies (Revell *et al*., 1998b; Sinclair *et al*., 2001) and it was not affected by the feeding level applied during mid-pregnancy. This fact suggests that the extra feed allowance during mid-gestation did not affect mammary gland development in gilts. However, two cases of MMA syndrome were observed in the S group and it would be convenient to find out if this was a consequence of the high feed intake provided during gestation. Moreover, the effects of this feeding practice should also be evaluated on multiparous sows, since the nutrient partition of multiparous sows during gestation is different compared to primiparous sows.

Protein reserves at farrowing have been positively related to both milk production and sow feed intake during lactation (Mahan, 1998; Kusina *et al*., 1999). In the present study, the extra feed allowance provided during mid-gestation did not lead to higher estimated protein reserves at farrowing (data not shown). However, the estimated body protein content at farrowing was significantly correlated with the average litter daily gain during lactation ($r = 0.31$, $P = 0.012$), whereas the estimated fat content at farrowing showed no relation, suggesting the importance of protein reserves on gilts' performance in these new genotypes.

Neither weaning to oestrus interval nor the farrowing rate and total born at the second parity were affected by the gestation feeding level. These results were not unexpected since tissue mobilization during lactation was not different between groups. Body weight loss was near to the maximum of 10 kg suggested as an acceptable loss (Noblet *et al*., 1990) and less than the 10 to 15% of their BW at farrowing found by other authors (Aherne and Kirkwood, 1985; Prunier *et al*., 1993).

In conclusion, increasing feeding level during mid-pregnancy in gilts showed beneficial effects on the percentage of sows within the optimal range of fat reserves at farrowing and at weaning. In the present experimental conditions, the negative relationship between BF at farrowing and feed intake during lactation seems still evident although not affecting body reserves loss in lactation. Moreover, the time window when the feed supplementation took place in this experiment, could have been determinant in order to influence foetal development, since small but consistent differences on litter and average piglet weight at birth were found. However, the whole benefit of this feeding strategy on productive and reproductive performances may not justify the extra feed expense. Further investigations are needed to clarify the effects of this practise on the progeny outcome post-weaning and on the whole sow lifetime performance.

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